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MAPPING AND ANALYZING ACOUSTIC SURVEYS' RESULTS: A GIS APPROACH

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INTRODUCTION C.I.B.R.A. is a research group whose main interest is in the study of underwater sounds related to marine mammals and in the development of acoustic detection and analysis technologies. The "acoustic" aspect in wide area studies, critical habitat identification and population distribution has become more and more popular. According to our experience it is a difficult task to integrate, in one scheme, acoustic evidences with other data sets like remote sensing or seasonal fluctuations models, and scientists often fail to provide one general clear picture of the study area. Nowadays, more than expanding scientific knowledge about acoustic communication and echolocation in marine mammals, researchers' interest is shifting to more comprehensive research topics. The methodology used to consolidate on a GIS acoustic data, historical data and measured or modeled parameters is hereafter described.

MATERIALS AND METHODS Starting from 1998 C.I.B.R.A. reasearch group has been involved in the NATO SACLANT Center SOLMaR research program (Sound Oceanography and Living Marine Resources). This program is aimed at evaluating and minimizing impact of human activities on marine life and marine mammals in particular. An extensive 24hrs/day acoustic detection classification is carried out by our team during 20 day/year periods spent at sea within this project. The on-field periods are spent on the R/V Alliance, a large NATO Research Vessel offering unique facilities like large scientific labs, selected crew that supports uninterrupted cruising, state-of-the-art acoustic sensors towed by one of the most silent ships ever designed. During this cruises four or five people shift at an acoustic monitoring and recording equipment, performing a continuous recording and classification of the detected signals.
Acoustic detections are categorized using a slotted time axis *vs.* abundance of simple sound categories. Each record in the database describes the events occurred in our time-slot, a 1 minute period. Events are described using simple acoustic categories. The researcher gives a quantitative value ranging from 0 (not present) to 3 (present and very abundant) to each of these categories. The same is made with a qualitative index (signal strength) for each category.
The huge data amount resulting from continuous acoustic recordings and classification, together with navigation data, visual sightings, research effort indexes, acoustic and oceanographic parameters and satellite remote sensing, are flushed to and organized in a GIS database in order to perform further analysis and have area over-looks.

RESULTS AND DISCUSSION Time-slotting is indeed a useful strategy when trying to fill a database with events that stream uninterrupted along the time axis. This strategy throws a bridge among researches where continuous acoustic monitoring is chosen and those with acoustic samples taken at discrete stations. Along the continuous audio flow the researcher's "virtual" station will be the one delimited by the duration of the slot.
Once filled with data, tables become a detailed index of detected signals. As all data are geographically referenced, by plotting tables on a map the researcher obtains in one step a view of his research effort and his detections.
Acoustic categories must be as few as possible, directly deriving from a previous knowledge of the study area, and easy to spot for the operator. They must be meaningful for the research as well. Operators must be trained to reliably identify categories with their quality and quantity characteristics. Acoustic classification can be repeated in post-processing on tapes (or sound files), to check for missed events and to average classifications made by different researchers whose attitude could be to mis-estimate certain event categories.
Data tables can be used to search for event sequences. They are the ultimate index of researcher's recordings. From tables it is easy to go to points of interest on recordings.
Finally every table can be plotted on maps, and together with acoustics every other georeferenced parameter can be overlaid. Any record in the database or any sound cut can be thereon accessed starting from plots on maps.

CONCLUSIONS A GIS is basically a database that deals with georeferenced data, and it is able to geographically plot them or to plot results of mathematical, logical and statistical operations on those data. Our experience has shown us the feasibility of real-time recording, analysing and mapping acoustic data, together

with slowly changing environmental parameters, on a GIS. Moreover detailed indexes of detections and recordings are shown along the ship's track on maps.
As a GIS, performing operations, is able to look for relationships, it can be useful while testing hypothetical correlations among parameters. Good computer skills are required to obtain valuable results, but user interfaces are anyway rapidly evolving. Trained operators are still needed to classify acoustic signals, nevertheless this system is ready to be matched with automatic recognition routines as soon as reliable tools will be available.
Plotting acoustic data together with other parameters gives researchers an excellent opportunity to spatially organize their findings, to check for correlations and to plan further researches.

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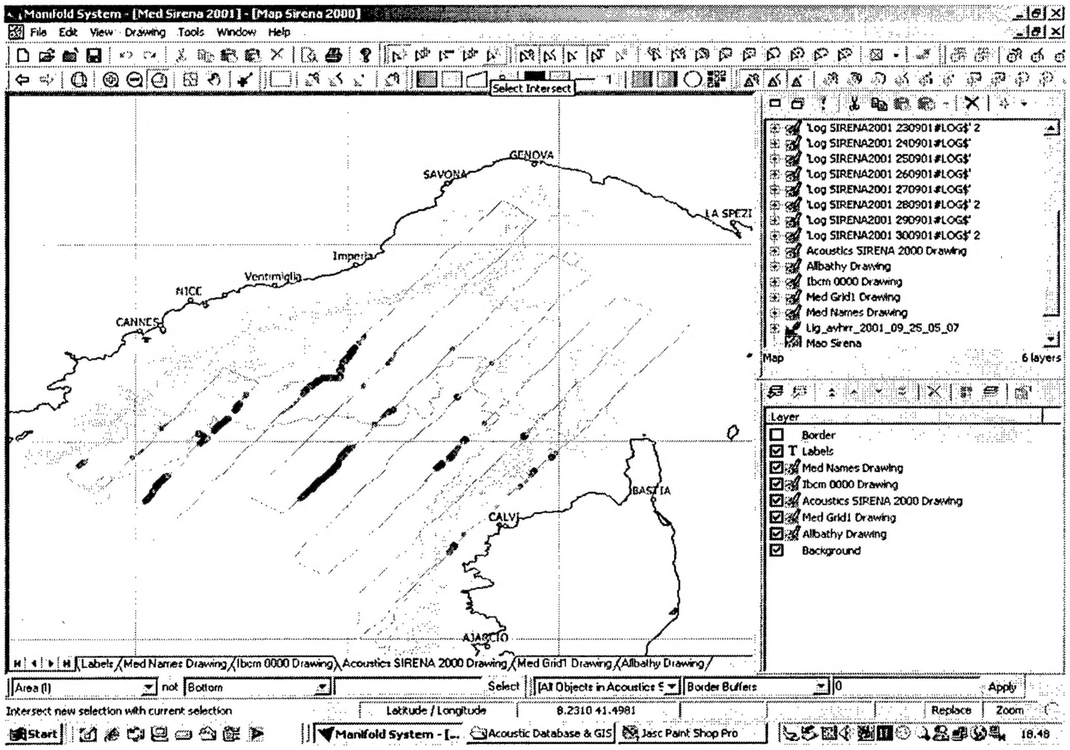
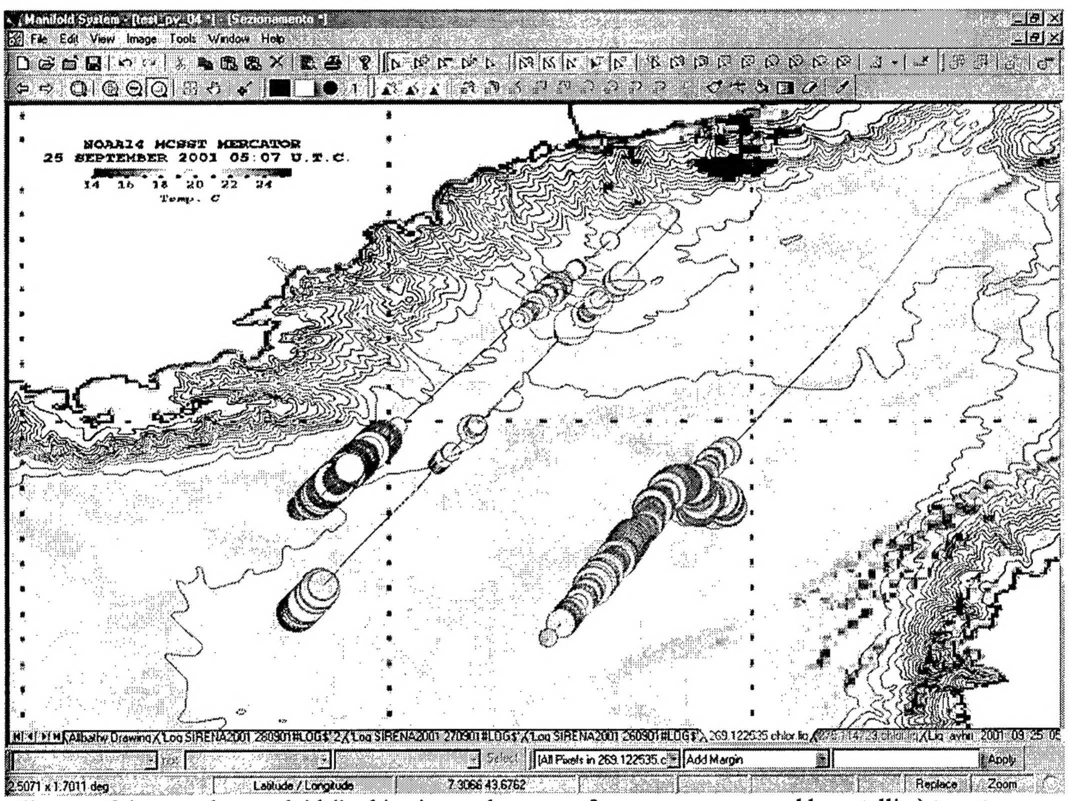


This simple map shows, for example, the occurrence of acoustic sperm whale detections along the ship's track.



All sorts of data can be overlaid (in this picture the sea surface temperature read by satellite) to get an area quickview and when meaningful correlations are tested.